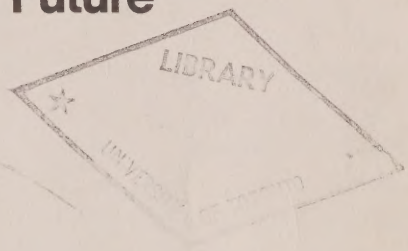
Ontario

Ontario's Energy Future



"I am not convinced that the public is sufficiently aware of the potential seriousness of our energy supply prospects... That is the reason for this report... to advise the public as to our energy future."

Hon. James A. Taylor, Q.C.
Minister of Energy

April 1977

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ONTARIO'S ENERGY FUTURE

MINISTRY OF ENERGY
APRIL, 1977

PREFACE

In June of 1973 Hon. W. Darcy McKeough prepared a report on Ontario's energy prospects.

In that report he commented:

> "It bears repetition that the problem of a secure supply of clean energy for Ontario is many-faceted. In the months and years ahead it will engage the concentrated attention of the Government of Ontario. Negotiations involving security of supply and price are likely to be difficult and protracted. Regulation of utilities will become more, rather than less, complicated. The interests of the province will be served by major efforts in the direction of conserving energy. Continued monitoring of policies and facilities in terms of their impact on the environment will be necessary".

A few months after Mr. McKeough delivered this report to Premier Davis war broke out in the Middle East, an embargo was placed on the shipment of crude oil from the Arab countries to many of the industrial communities and the Organization of Petroleum Exporting Countries -- O.P.E.C. -- demonstrated its market strength by quadrupling the price of crude oil on the international market.

Since that date the answers to questions related to the security of crude oil and natural gas supplies in the world have become more tentative and uncertain, rather than less.

It is not likely that unanticipated technological developments or unexpected petroleum discoveries will resolve the problem of energy supplies and permit the industrial world to continue unabated its consumption of

energy. Furthermore, Ontario imports from other provinces or other countries 80 per cent of the energy consumed and cannot gamble the future on long shots; the future must be planned and one of the urgent products of planning must be the securing of a supply of clean and useable energy sufficient to satisfy our anticipated requirements.

This won't be easy and it won't be cheap. Pipelines from the frontier regions, like large nuclear generating stations, are multi-billion dollar undertakings. Over the next one or two decades Canada can expect to have to buy a good many billions of dollars worth of both. Large expenditures will also have to be made in research development and demonstration related to the renewable energy sources upon which we will ultimately have to depend. Ontario will not avoid very large energy investments.

The McKeough report further noted: "... it is vitally important, if unfortunate tensions are to be avoided, that the public be kept fully informed as to developing problems and proposed solutions".

I accept that advice. There is no question that over the next several decades energy production, consumption and conservation will demand more of us than it has over past decades; energy will continue to be expensive and the cost of providing the generating, converting, transporting, refining and other facilities will claim a larger and growing proportion of our available capital.

Those increased costs will relate to our traditional energy sources. But fossil fuels, in particular, have a

limited life. Ontario, like all other industrialized regions or countries, will have to make a greatly increased commitment to research and development designed to develop new methods of converting renewable energy into useable forms.

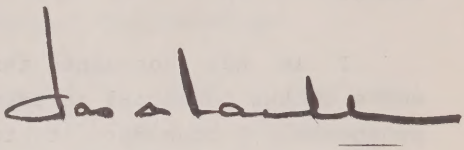
I am not convinced that the public is sufficiently aware of the potential seriousness of our energy supply prospects. I consider it to be my clear and minimum responsibility to assure that the concerns of the Government of Ontario and of my Ministry are fully stated and are available to the public.

That is the reason for this report. It has been prepared for one good and sufficient reason -- to advise the public as to our energy future.

That future must be secured for the people of Ontario. The public and private sectors share a clear responsibility to develop the research and energy producing facilities that will continuously improve our prospects. If the public takes very seriously the need to use energy efficiently and economically we will achieve time in which to find acceptable answers.

But first the public must be aware of our energy prospects. This report is not prepared for engineers, scientists and technologists and they may find that, in important respects, it over-simplifies. I anticipate that criticism and it does not disturb me; this is a report from the Ministry of Energy to those who flick the electric light switches and drive the cars of the province, who pay the taxes and the energy bills and who have the capability of reducing the amount of energy they use and that we, as a province, will require in the decades ahead.

Our energy future will not be a carbon copy of our energy past. To the extent that we can anticipate the future we can improve our chances of adapting to it. That is what this document is all about.



JAMES A. TAYLOR, Q.C.
MINISTER OF ENERGY

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SECTION I

INTRODUCTION

The key fact with respect to the energy that is powering the world today is that it is being consumed and not renewed or replaced. The major sources of energy are the oil pools and natural gas fields of the world. Both are being emptied at a rate that is likely to result in their effective depletion within a few decades.

As world industrialization increases and under-developed countries become more developed the requirement for energy and the pressure on the world energy supplies will increase. There is no apparent way that this growing energy demand can be satisfied with crude oil and natural gas for more than a few decades.

Canada shares the prospect of energy shortages with the other countries of the world. Ontario, within the Canadian context, is less advantageously placed than those provinces possessing large resources of crude oil, natural gas and coal.

In Canada -- and this is true of some other countries -- there are large deposits of coal, oil sands and heavy oils. There is enormously more energy in these three sources in Canada than in Canada's known reserves of conventional crude oil and natural gas. But to use them as a substitute for conventional crude oil and natural gas is neither easy nor cheap. A limited amount of the oil sands can be exploited through mining but the largest proportion of these oil-soaked sands are too deep to be mined at present at an acceptable cost. Some means must be found that will permit the oil to be removed without moving the host sand; no technology now exists that makes this economically and commercially feasible.

The heavy oils are too viscous to pump underground. They must be made to flow first if they are to be pumped to the surface at all. This can be accomplished by injecting steam or heat from other sources, but no recovery process that has been proven to be feasible in commercial-sized plants has been developed.

Enormous deposits of coal occur throughout the world, including the three westernmost provinces of Canada. But converting these western deposits into useable energy for Ontario poses formidable problems. Mining is costly and local citizens frequently are deeply concerned as to the environmental effects. Even if the coal could be mined in sufficient quantity the cost of transportation to the markets of Ontario is a constraint and, further, the physical movement of enough coal to power this province would be a monumental undertaking.

More effective utilization of coal is likely to have to await the development of economical and efficient technologies that will permit conversion of coal to a synthetic oil or a synthetic gas. That can be done today but at a prohibitive cost. Ultimately a means must be found for economically extracting the energy content of coal in the ground if the full potential of the resource is to be tapped.

Uranium atoms are fissionable and their fission produces heat which can be converted into steam which drives turbines to produce electrical energy. Ontario has substantial deposits of uranium within its borders. The province is increasingly relying upon uranium as the fuel for its electrical generating stations and this trend is likely to continue.

Uranium reserves, however, are not unlimited and uranium, like coal, oil and natural gas, can eventually be depleted.

It is possible that the technology to increase the energy recovered from uranium will be available prior to the complete depletion of uranium resources. Using the presently available technology a nuclear generating station uses only about one per cent of the energy that exists in uranium and the technologists are working on "advanced fuel cycles" based on existing CANDU technology that would result in the release of very much more energy -- up to 50 times -- from the existing uranium resources.

There is a persistent public concern over the proliferation of nuclear stations throughout the world. And, further, nuclear generating stations are costly to construct. However, between now and the end of the century an increasing amount of the energy used in Ontario will be in the form of electricity. An increasing proportion of that electricity will be produced through nuclear generation because there is no real option.

Nuclear generation, important though it is, is not a complete substitute for fossil fuels -- crude oil, natural gas and coal. Electricity is not a ready substitute for the fuels that drive, for example, automobiles and aircraft.

Energy deficits will have to be compensated for by energy produced from renewable sources -- such sources as the sun, heat within the earth, the fusion of hydrogen atoms. But the technologies that would permit the economical production of solar, geothermal and fusion

energy awaits development. One or all will be vitally important in the long term because they will have to be, but it is projected that by the year 2000 these renewable forms will be capable of supplying only two or three per cent of the energy consumed in the world.

There is and always will be a very large element of speculation in any long term projection of energy sources, as well as of the amounts that will be produced and required. Fossil fuels are buried, frequently many thousands of feet below the surface of the earth. There is no procedure that will permit a precise inventory prior to discovery and development. Even then, there is a continuing uncertainty as to the amount that can actually be recovered.

Uncertainty also applies to the development of new technologies. The energy from the sun is virtually unlimited and the energy supply problem would be greatly reduced if a technology was developed that permitted the economical collection of solar energy in commercial quantities that could be converted to transportable and storable forms. A major breakthrough in the direction of the controlled fusion of hydrogen atoms would be equally important. The relevant technology may or may not be developed. At best, the lead time will be very long.

Time is not on the side of those requiring increased quantities of energy. In Canada the conventional energy sources that are readily exploitable are being depleted. Supplemental energy, whether achieved through the construction of pipelines from the geographic frontiers,

synthetic oil or gas from oil sands, heavy oils or coal or the development of a technology for producing energy from renewable sources will take years or decades from the initiation of the project to its successful completion. And there is no assurance, at least in some cases, that even a major effort will achieve a major success.

The time that is available must be used effectively. In a very real sense the fate of humanity rests upon the outcome of the race between the depletion of the world's non-renewable energy sources and the development of renewable alternatives.

SECTION II

INITIATIVES IN ONTARIO

For more than a century, successive Governments of Ontario have been aware that assuring a secure and adequate supply of energy was crucial to the province. As a consequence heavy investments have been directed toward the security of energy supply.

Early in this century, under the leadership of Premier James Whitney and the aggressive inspiration of Sir Adam Beck, the Government of Ontario opted for public power and, through the agency of the newly-created Ontario Hydro, the generation and wholesaling to the local utilities of electric power. Today Ontario Hydro, on behalf of the people of the province, manages one of the large electrical generating and distribution facilities of the world, involving a total investment of something over $8 billion.

In the 1950s, notwithstanding the fact that crude oil could be purchased from foreign sources at less cost than it could be purchased from western Canada, the Government of Ontario strongly supported the connection of the oil fields of Alberta to the industrial market of Ontario. In the same circumstances, a few years later, Ontario supported the construction of the TransCanada PipeLine to transport natural gas from the same source to this market. Both decisions contributed to Ontario's security of energy supply.

In the 1950s and early 1960s, before the CANDU technology had reached the commercial production stage, the Government of Ontario through Ontario Hydro concurred in the demonstration and prototype development by the federal Atomic Energy of Canada Limited of the CANDU nuclear system in Ontario. Subsequently, the Government supported construction of the first two units of Pickering "A" Nuclear

Generating Station in 1964 by taking part in the joint Federal-Provincial-Ontario Hydro capital funding of this project, and approved the Ontario Hydro commitment to undertake the second two units of the Pickering "A" Station in 1966 and the four-unit Bruce "A" Nuclear Station in 1968. Following the successful initial operation of the Pickering "A" Station in 1971 to 1973, the Ontario Government approved construction by Ontario Hydro of the four unit Pickering "B" Station in July 1974 and the four-unit Bruce "B" Station in 1975.

The apparently safer course would have been to continue with the proven oil and coal-fired thermal stations. Had this been done Ontario's electrical energy sources today would have been much less secure. Ontario's investment, as on previous occasions, was designed to increase the security of the province's energy supplies.

Growing concern as to future energy prospects led to the appointment in 1971 of the Advisory Committee on Energy under the chairmanship of the late Dr. John Deutsch. This Committee, demonstrating a high degree of prescience, warned of the imminence of crude oil and natural gas shortages and the probability of energy price escalation at a time when other Governments in Canada had still failed to recognize the emergent trend.

Also in 1971 a task force -- Task Force Hydro -- was appointed and undertook a very detailed examination of a wide range of matters related to Ontario Hydro and assessed its continuing capability to best serve the electrical energy needs of Ontario.

In 1973 Premier William Davis instructed his then Parliamentary Assistant, W. Darcy McKeough, to examine the energy management and control structures in Ontario and to advise as to changes that might accommodate the developing price and supply trends. In June of that year a report was presented. It led to the creation of a Ministry of Energy; the strengthening of the Ontario Energy Board; the creation of the Ontario Energy Corporation; and increased commitment to the efficient use and conservation of energy and an intensification of research and development activities related to energy.

To develop future energy supplies the Government of Ontario, through the Ontario Energy Corporation, associated itself with the Governments of Canada and Alberta and three private petroleum companies in the Syncrude Project, a project for the construction of an oil sands plant in Alberta. In addition, it is a participant in the research study designed to prove the economic and technological feasibility of bringing natural gas from the Arctic Islands to the markets in the south, including industrial Ontario.

The Ontario involvement in these two projects --Syncrude and Polar Gas -- is consistent with the historic objective of assuring security of energy supply. The improvement of the technology for the extraction of oil from sands and the establishment of the feasibility of transporting natural gas from the Arctic Islands could make an important contribution to assuring that the energy that will be needed over the next few decades is, in fact, available.

McKeough noted in his report that the depletable sources of energy cannot provide long term, secure supplies of energy. An intensified commitment to energy conservation would assure that the supplies that do exist are not irresponsibly dissipated; an intensified commitment to research and development, designed to develop the technology for the extraction of energy from sources that are renewable, would increase security through enhancing the prospect of alternative energy sources.

References to the importance of a deepened commitment to conservation and to the increasing of energy-related research and development will recur throughout this report. To a large degree the reason for this document is to underline and urge a public and governmental commitment in these two vital areas.

SECTION III

ENERGY FROM CONVENTIONAL SOURCES

In the long term there is no real doubt that Ontario -- in common with most of the countries of the world -- will have to rely upon energy from such renewable sources as the sun or such other sources as fusion and advanced fuel cycle fission that, although not strictly renewable, will be capable of supplying energy for such a long period of time that they cannot be classified with the non-renewable sources of energy that we use today.

The conventional sources of primary energy are crude oil, natural gas, coal, uranium and hydraulic energy -- electricity generated through the use of falling water. For all practical purposes these sources now provide all of the energy that we use. Of the five sources only hydraulic energy is renewable.

Almost two-thirds of the electrical energy used in Ontario is produced in thermal plants that are fuelled with fossil fuels or uranium; in other words, most of our electrical energy is produced in thermal plants fuelled with non-renewable energy.

Apart from deposits of uranium and minor occurences of natural gas and coal, Ontario has no indigenous non-renewable energy. Most of our crude oil and natural gas is moved by pipeline from Alberta and most of our coal, predominantly used for the generation of electricity and in the manufacture of steel, is supplied from sources in the eastern United States. A limited amount of coal is now being supplied from western Canada, an amount that, in spite of its very high cost relative to coal from the United States, will likely gradually increase.

The proportions of the various forms of primary energy used in Ontario in 1976 (preliminary figures) were as follows:

Oil	39.8%
Natural Gas	24.1%
Coal	14.7%
Electricity (hydraulic)	12.9%
Uranium	5.6%
Electricity (purchased)	2.9%

The security of supply of each of these sources over the next twenty-five years and more is very important to the province.

Projections of future supply, judged on the experience of the past, are uncertain and imprecise. Of necessity they are based upon present knowledge that is incomplete and assumptions as to the future that contain a large component of judgement and even of speculation. But, in spite of their inadequacies, they are the only tools available and must be used.

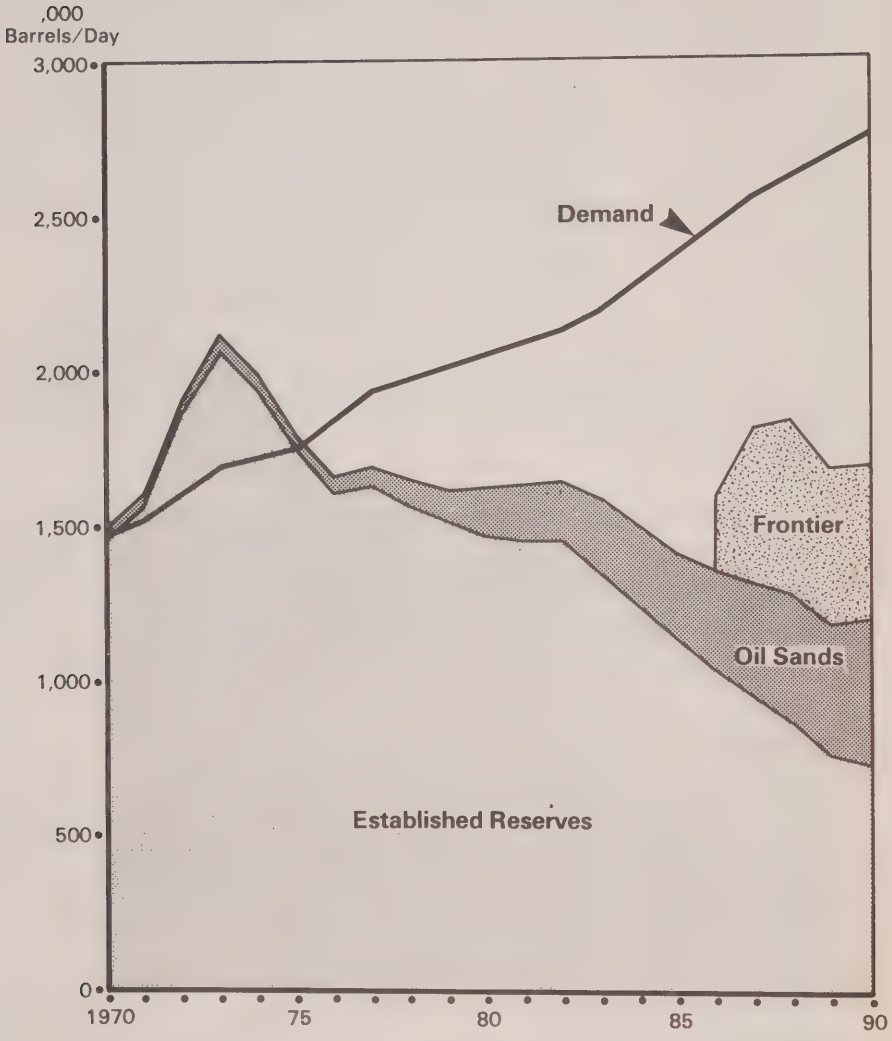
There seems little purpose in adding one further set of projections to the large number that have been made and this report will accept, with some reservations, recent projections by the federal Department of Energy, Mines and Resources.

Crude Oil

On the following page Figure 1 shows graphically the estimate of the Department of Energy, Mines and Resources as to the prospective supply of and demand for crude oil in Canada.

Figure 1

Domestic Crude Oil Demand And Availability



NOTE:

1. High price scenario which leads to projection of greater supply than the alternative low-price scenario.
2. Demand shown is the midpoint of assumed high and low economic growth cases.
3. Includes liquified petroleum gases (LPG's)

Source: Energy Mines & Resources Canada, An Energy Strategy For Canada, Page 83

Other projections, examined as a background to this study, differ in detail as a result of differing assumptions but all projections have one point dramatically in common. Within a very few years Canada will not be producing enough crude oil from domestic sources to satisfy the requirements of Canadian users.

Notwithstanding differences in detail, the expectation is that Canadian oil supplies from proven domestic sources will not be sufficient to satisfy total Canadian demand and that the deficit will increase over the forecast period. If the various conclusions are averaged the deficit that is indicated is about half a million barrels a day by 1980, increasing to as much as two million barrels a day by 1990.

It is assumed that in the years beyond 1990 -- which is now only 13 years in the future -- the deficit will continue to increase. Unless some other form of energy replaces much of the crude oil that we consume, it follows that Canada will have to become a very big buyer in the world crude oil marketplace.

There is an obvious uncertainty as to price. Given the oil price increases in the international market over the past half decade, oil could be very costly. Two million barrels a day at the current world price -- and by 1990 it is likely to be higher -- would cost Canada about ten billion dollars a year. But there is another uncertainty that is even more serious: world stocks of crude oil are being depleted very rapidly and there is no assurance that the quantities of crude oil that Ontario might wish to purchase will be available on the world market.

Because Ontario is highly industrialized and lacks indigenous sources of crude oil this is a more serious threat to this province than to most other provinces of Canada, particularly those that have crude oil and energy resources within their borders.

The projections of the amount of crude oil that we may require in Ontario in 1985 range from 640,000 to 820,000 barrels a day. The projected production of crude oil in Canada that year is about 1.2 million barrels per day -- about half the projected Canadian crude oil consumption. The proportion of the Ontario supplies that will be available from domestic sources will depend upon the accuracy of these projections and, of course, on the amount of the oil produced in the western provinces that is required for the use of the provinces to the west of Ontario.

At the present time -- apart from 250,000 barrels a day shipped into Montreal from western Canadian sources -- the provinces to the east of Ontario rely on oil supplies from the international market, partly matched (and to a rapidly declining extent) by Canadian crude oil exports to the United States. Most of Ontario and the provinces to the west are supplied from Canadian sources.

It is evident that, as western consumption of oil increases and domestic production declines, Ontario will be the province that will be forced to the world market for varying amounts of crude oil. Subject to changes in production and consumption of crude oil in western Canada, Ontario will have to rely upon the international market for a greater or lesser proportion of its crude oil requirements.

Natural Gas

Figure 2 on the next page, illustrates the estimate of the Department of Energy, Mines and Resources of the relationship of the supply and demand for natural gas in Canada.

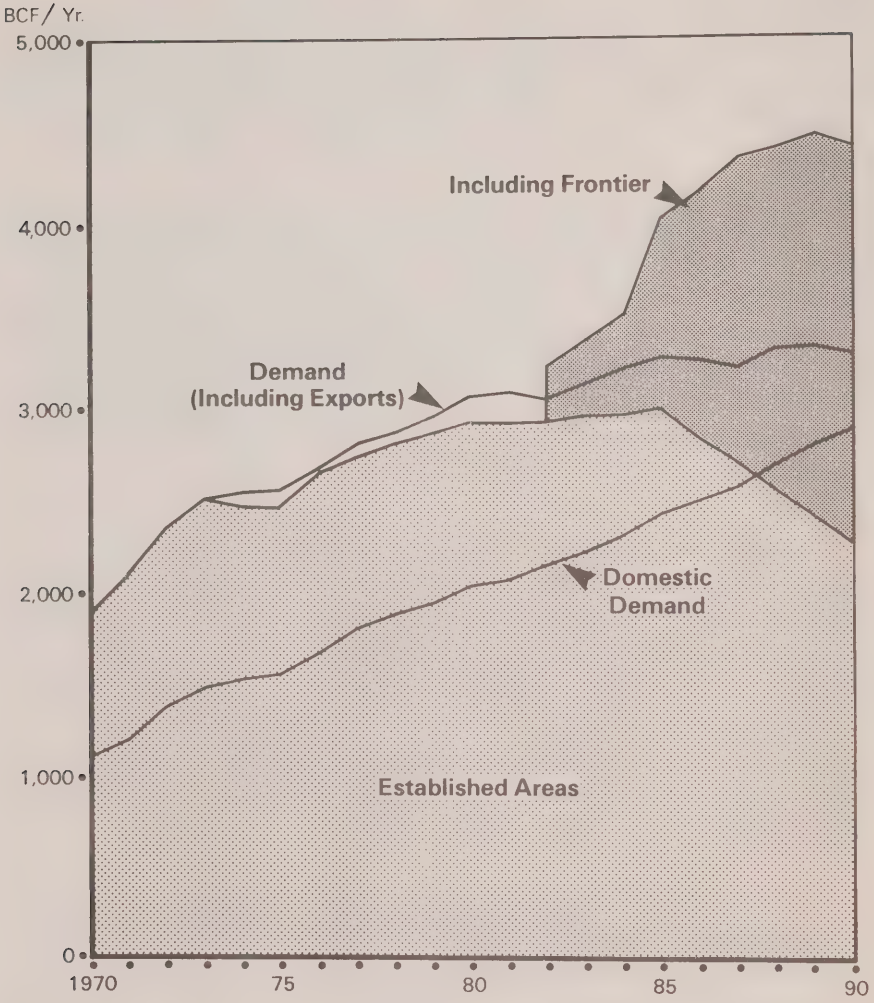
As is the case with crude oil, different projections contain significant differences resulting from varying assumptions and judgements. But, again, the broad conclusions are parallel. And the supply/demand relationship that emerges -- given frontier sources of natural gas are connected to the industrial markets of the south -- are less discouraging than the crude oil supply/demand projections.

There is, however, an important assumption built into the projections. Examination of Figure 2 will reveal that the Department of Energy, Mines and Resources has assumed that the natural gas pipeline from the Mackenzie Delta and the Beaufort Sea will be completed in time to deliver natural gas to southern markets by 1982 and that this will be followed in 1985 by the completion of a pipeline connecting the natural gas resources of the Arctic islands.

No decision has been made at the present date by the Government of Canada as to the approval of the construction of either of these proposed pipelines. Clearly the natural gas supply prospects of Canada and Ontario will be enormously affected by the decision as to whether or not either of these pipelines should be built and how soon that decision is taken.

If the natural gas resources of the Mackenzie Delta or the Arctic islands are not destined to be available by the

Natural Gas
Demand And Availability



NOTE:

1. **High price scenario which leads to projection of greater supply than the alternative low-price scenario.**
2. **Demand shown is the midpoint of assumed high and low economic growth cases.**

Source: Energy Mines & Resources Canada, An Energy Strategy For Canada, Page 84

mid-1980s, shortages of natural gas will ensue. If the decision is taken not to construct these pipelines or to find alternative transportation means most of the projections are in agreement that available supplies will not be adequate to satisfy the requirments of the middle to late 1980s and beyond.

At the present time supplies of natural gas are more than adequate to satisfy current demand. As domestic crude oil sources deplete and there is an effort to substitute natural gas to compensate for the projected crude oil deficit any surpluses will be absorbed.

Canada has had relatively more success in the search for domestic supplies of natural gas than in the search for crude oil. Natural gas is the energy form that is almost universally assumed, in all projections, to be the energy source most capable of substituting in some major part for declining supplies of fuel oil produced from crude oil.

The use of natural gas has increased rapidly since its introduction to the Ontario market in 1958. By 1971 it had achieved the position of being second only to crude oil in its importance as a fuel source in the province. By 1975 it accounted for 24 per cent of the primary energy consumed in Ontario.

Approximately 97 per cent of the natural gas used in Ontario comes from the western Provinces. In 1975 a total of 0.67 trillion cubic feet was consumed -- about 50 per cent of all the natural gas consumed in Canada. It is less than that percentage of all natural gas produced in Canada because, under contracts that will expire in 1993, Canada exports almost a trillion cubic feet a year of natural gas to the United States.

In the absence of natural gas from frontier sources there are important constraints on the increase of deliveries of natural gas from the traditional sources in western Canada. Increases would necessitate an increase in the capacity of the TransCanada PipeLine system and, unless the additional supplies are of long enough duration to absorb the cost of such an increase, its economic justification will be difficult. The fact that consumption is expanding in the western Provinces will reduce the quantities available for export to other Canadian provinces. Further, unless additional supplies are expected to maintain deliveries for a long period of years it will be difficult to market the additional, short term natural gas. (A new potential consumer is not likely to choose natural gas over oil unless convinced that supplies will be available far into the future.) A result could be short term surpluses of natural gas in Canada coincidental with increasing reliance upon international crude oil supplies.

The fuel that will compensate for deficits of other energy sources in Ontario between now and the mid-1980s -- when frontier natural gas might arrive -- is likely to be crude oil from world markets. If frontier pipelines are not connected by that date reliance on imported crude oil will continue to increase.

Irrespective of whether the decision by the Government of Canada is to grant or deny permission to build pipelines that will connect the natural gas resources of the frontier to the industrial markets of the south, such a decision is urgent. In the absence of such a decision it is difficult for Ontario to make plans designed to assure security of future energy supplies.

Coal

The Department of Energy, Mines and Resources projects that the consumption of coal in Canada will increase from an estimated 28 million tons in 1975 to about 58 million tons in 1990 -- an increase that would result in coal retaining but not increasing its share of the energy market in Canada. Most of this increased consumption will be for the purpose of fueling thermal electrical generating stations.

Canadian coal is located in limited quantities in the Atlantic Provinces and in very large quantities in the three westernmost provinces. Proven recoverable reserves in 1976 totalled 12 billion tons -- a resource base that would last more than 400 years at the 1975 production level of approximately 28 million tons.

Consumption will not remain at 1975 levels and, like all such global figures, the 400 years means little. But it is illustrative of the fact that Canada does have large coal reserves.

Coal accounted for 21 per cent of the primary energy consumed in Ontario in 1960 and, challenged by crude oil and natural gas, had declined to about 15 per cent of a very much larger market by 1975.

In 1975 Ontario consumed about 8 million tons of thermal coal, used for conversion into electricity, 7 million tons of metallurgical coal for the manufacture of steel and a million tons for various other purposes. Almost all of this coal was imported from the eastern United States.

Ontario Hydro is and will continue to be the major consumer of coal in Ontario, so this discussion will focus on thermal coal.

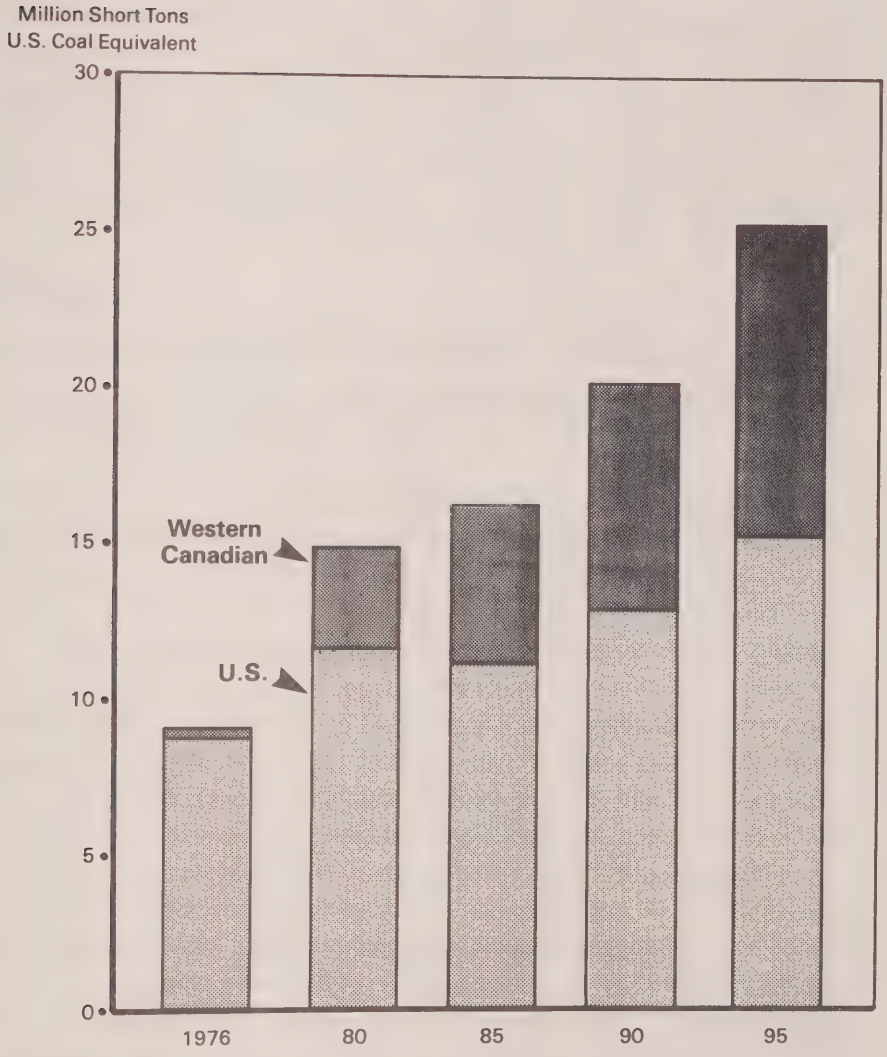
Figure 3, which follows, shows the expected demand and source of Ontario Hydro's thermal coal from the present to the mid-1990's.

As Figure 3 indicates, almost all of Ontario Hydro's current consumption is purchased in the United States. In spite of the fact that, in equivalent energy terms, coal from western Canada is 50 per cent more expensive than coal from the historic suppliers in the United States, recent arrangements have been made to obtain coal from minefields in western Canada. If those expectations were realized, by 1990 Ontario Hydro would be purchasing 35 per cent of its coal from western Canadian sources, with the remainder continuing to be imported from the United States.

Given the supply and price prospects that apply to crude oil and natural gas, quite apart from the more specific and specialized uses for which they will be urgently required, Ontario will need to depend primarily upon uranium and coal as fuel sources for additional electrical generation. Nuclear generating stations, which are fuelled with uranium, are more costly to construct than coal-fired stations but the operating costs, at the present and for the forseeable future, are lower. And the capital cost advantage of coal-fired generating stations has been reduced to the extent that the needed pollution devices are very costly. These and other considerations have led to an Ontario Hydro policy of installing future nuclear and coal-fired electrical generating capacity in a ratio that favours nuclear.

Figure 3

Estimated Ontario Hydro Coal Demand 1976-95



NOTE:

1. Consumption based on generation program LRF48 and load forecast 760209 less March 8, 1976 conservation targets.
2. Projections beyond 1980 reflect anticipated sources as well as firm contracts.

Purchases in western Canada are designed to provide a second source of thermal coal. There is no anticipation that United States' sources -- for which the contracts run to the mid-1980s -- are insecure or that the contracts will not be extended. At the same time, having an available alternative source appears to justify the purchase of the higher cost western Canadian coal.

Coal from the United States and the western provinces is not entirely interchangeable. Different furnace designs are required. But coal from western Canada has a lower sulphur content and this is an environmental advantage.

Unlike crude oil and natural gas, in which the adequacy of supply is an imminent and urgent problem, the coal resources are so large that effective depletion lies far in the future. Coal cannot, however, be viewed as an energy source for Ontario capable of compensating for the anticipated deficit of crude oil. Coal carries with it serious environmental concerns. Further, the coal-containing structures in western Canada are frequently complicated and mining procedures must be designed that will permit the recovery of the largest possible proportion of the coal in such deposits. Coal mining is not a preferred occupation, particularly underground, and manpower is a constraint on productions. Capital costs for mines are high and escalating. Lead times for the purchase of equipment and the bringing into production of new properties is very long. Some of the producing provinces are not interested in the rapid development of coal properties for environmental reasons, and because it does not serve their immediate provincial objectives. Transportation from the remote mines of western Canada is costly.

A clear distinction must be made between the existence of resources of coal and their availability as an energy source for use in Ontario. Coal is not a complete alternative to the forms of energy we now use and it must not be supposed that coal production could be expanded to fill the energy void implicit in the developing shortages of crude oil and natural gas.

Uranium

Apart from hydraulic sources for electrical generation uranium is the only indigenous primary energy source found in significant quantities in Ontario.

Proven uranium reserves in the province are adequate to fuel Ontario's existing and planned nuclear generating stations.

Given success in technological research that is proceeding in Canada and in several countries of the world, the effective life of Ontario's uranium resources as a fuel source could be greatly extended. Present nuclear generating facilities use a relatively small proportion of the fissionable material that occurs in natural uranium -- about one per cent in the case of the CANDU reactors used by Ontario Hydro. Success in the development of advanced fuel cycles using basic CANDU technology -- the details of which are complicated and not relevant to this discussion -- would enormously increase the amount of energy that could ulitmately be released from uranium and thorium.

If development and demonstration efforts proceed and are successful, Ontario will be well supplied with fuel for conversion to electricity. Even with the advanced fuel

cycles, however, Ontario's long term energy supply needs would not be fully supplied. Forms of energy other than electricity will be needed.

Electricity

Electricity is the one major energy form that is produced in significant quanitites in Ontario. It is, consequently, the only energy form relative to which the Government of Ontario can design policies with a minimum requirement for considering the decision-making power of other governments.

In 1975, 39 per cent of electrical energy supplied by Ontario Hydro was generated from hydraulic sources and 13 per cent in nuclear generating stations: in other words, more than half of the province's electricity was produced from sources indigenous to the province. The remaining electricity resulted primarily from the conversion of fossil fuels -- coal, oil and natural gas.

In the future the shift will be toward coal-fired and nuclear generating stations. Operating requirements and considerations of air quality, long term fuel costs and fuel availability will combine to favour nuclear sources over coal. On the other hand, as noted, there is evident public concern as to the environmental, safety and land use implications of expanded nuclear generating facilities in the province, quite apart from the high capital cost of nuclear facilities.

The problem of financing electrical generating facilities -- nuclear or coal-fired -- is a concern. Ontario Hydro gets over 85 per cent of its funds for expansion of Ontario's generating system from debt financing. The Ontario Government guarantees Hydro's debt. Lenders tend to view the financial integrity of Ontario Hydro and the Province of Ontario in terms of their combined debt. The combined borrowings in 1975 totalled $2.2 billion and the annual growth in outstanding debt for the period 1976 to 1982 was projected at 15.7 per cent while, concurrently, the average annual growth in the capital markets available to Ontario was estimated at about 10 per cent.

As a matter of prudence the Government of Ontario moved to check the growth of the public borrowings by both the Province and Ontario Hydro. In January, 1976, Hydro reduced its public borrowing to $1.5 billion annually for the period 1976 to 1978; later in the year it announced a $5.2 billion reduction in its planned expansion over the following decade. The reduction is to be achieved by cancelling some projects, delaying others and allowing the electrical reserve margins to decline from 29 per cent to 20 per cent over the ten year period.

During that time, Ontario Hydro will be able to satisfy an annual growth rate in electrical consumption of about 6.6 per cent. Given that the projection of the annual load growth, made prior to the imposition of the capital limitations, was 7 per cent, it is evident that any expansion of demand will have to be contained if the supplies of electricity are to be sufficient to satisfy the on-going requirement for electrical energy.

Many of the projections that have been made visualize electrical energy as a substitute for some part of the anticipated deficit in energy in other forms. This substitution may not be possible as rapidly as projected if the Government of Ontario finds itself faced with the necessity of extending Hydro's borrowing constraints. Even if the capital constraints were lifted, the long lead times required for new facilities would impose limits. Nevertheless, it is expected that the demand and supply of electricity will grow at a faster rate than that of total energy demand.

SECTION IV

ENERGY FROM NON-CONVENTIONAL SOURCES

It is not realistic to expect the decline in the production of crude oil and natural gas from conventional domestic sources to be reversed on any continuing basis. Additional production from existing fields may be achieved by infill-drilling and improved secondary and tertiary recovery techniques. But demand can be expected to increase while supplies from the conventional sources will continue to decline. Energy in the conventional forms will have to come from the northern and offshore frontier regions, deposits of oil sands, heavy oils and coal and from uranium-fuelled electrical generators.

The Department of Energy, Mines and Resources estimated that the development from these sources of the energy needed between 1976 and 1990 would, depending upon assumptions made, require from $170 billion to $180 billion 1975 dollars. And even such an expenditure is not likely to result in Canada regaining energy self-sufficiency.

Recognition of the prospect of a major dependence upon depleting sources of foreign crude oil has heightened the interest in the development of non-conventional energy sources and, in particular, any one of several solar based renewable sources. This increased interest is not limited to Canada -- it is equally true of most of the industrial countries of the world: there is a world-wide search for new energy technology that will result in the development of facilities that will economically exploit solar and other non-conventional energy sources.

The search is particularly urgent for Ontario because of its large dependence upon non-indigenous energy sources.

The term "renewable energy resources" is usually applied to those sources of energy that are dependent upon

energy from the sun -- solar radiation or the natural processes of the earth. In addition to direct solar energy this includes the conversion of the heat of the sun to electricity; it includes wind energy and biomass energy -- the production of fuel from biologic material; it includes tidal and wave energy -- the production of electricity from the massive movement of water; it includes geothermal energy -- tapping of heat within the earth; it includes hydraulic power -- the generation of electricity through the use of the power of falling water.

With the exception of hydraulic power none of these solar sources contribute energy in significant quantities today. As noted, increasing research and development expenditures are being made with the objective of developing technologies that will permit the economic production of increased amounts of energy from renewable sources. The fact the sources of the energy would be self-renewing and would not be a significant source of pollution means that accomplishment is urgent. But few commercial successes have yet been achieved; in this century renewable energy sources other than hydraulic power will continue to play a minor role as an alternative to the non-renewable energy sources that we use today.

It is the opinion of informed people in Canada and the United States that renewable energy sources will contribute little to satisfying our energy requirements through the end of this century.

The United States Energy Research and Development Administration predicts that by the year 2000 renewable energy sources other than hydraulic -- principally solar space heating (1.2 per cent) and fuels from biomass (2 per cent) -- will contribute about 4 per cent of total United States' energy needs. It has recently been estimated by the

United States Government that further additions from central solar and wind electric systems may increase this contribution to 7 per cent of total United States' energy needs.

The Department of Energy, Mines and Resources predicts that over the next quarter century the impact of renewable resources on Canada's energy supplies will be small.

The Ministry of Energy is of the opinion that a steady growth is likely to occur in the use of solar energy and there may be an increased use of forest residues and municipal waste, supplemented by indirect energy savings through the reclamation and recycling of materials, but the effect of all combined in the year 2000 will probably be equivalent to only 1 or 2 per cent of the Province's current total energy demand.

The long term impact of solar based renewable energy resources will depend on the technical and economic breakthroughs that result from Government and private sector research, development and demonstration in the next two or three decades.

Solar based renewable energy sources have a place in an integrated energy supply/demand strategy for the future. Indeed, solar energy is now being used for space heating. Increased use will depend upon relative costs. Utilization of renewable energy sources can be expected to grow as a means of supplementing conventional energy sources, particularly for local, point-of-use applications.

But, other than for such uses the Ministry of Energy is of the opinion that prior to 2000 it is quite unrealistic to suggest that solar, wind and biomass energy will offer a broad alternative to coal, crude oil, natural gas and electricity. Our near term energy future will depend upon a continuing supply of these energy commodities and, although efforts to achieve economy in the production of energy from renewable sources must be intensified, the reality for the period to 2000 is that we will have to secure our energy from the sources of the present -- crude oil, natural gas, coal and electricity.

SECTION V

ENERGY CONSERVATION AND EFFICIENCY IN ENERGY USE

Energy is destined to become increasingly scarce and expensive. The economic health of Ontario, environmental considerations, the extension of the life of the resources of oil and natural gas, the reduction in the need for capital investment in energy supply projects and prospects as to energy availability combine to underline the urgent importance of reducing the wasteful and unnecessary use of energy.

The Government of Ontario is a leader in the conservation and efficient use of energy in Canada, with each Ministry playing a role in its own area of responsibility.

The main role of the Ministry of Energy is policy development and the co-ordination of the Energy Management Program of the province to ensure the proper priorities for the Government's conservation program. The objective is to reduce by one-third the rate of growth of energy consumption in Ontario by 1980. Towards this end the Ministry initiates, co-ordinates and funds energy management projects. Ultimately, zero growth in energy consumption per capita may be an achievable objective.

The main involvement of the Ministry of Agriculture and Food, for example, is to reduce energy used in farm operations, particularly in greenhouse operations, corn and tobacco drying and in the ventilation and heating of farm buildings.

The primary undertaking of the Ministry of Colleges and Universities is to improve the heating, ventilation, air-conditioning and lighting of post-secondary education buildings across the province. It is anticipated that a five to seven per cent saving in energy consumption is possible through improved operating procedures.

The main contribution of the Ministry of Consumer and Commercial Relations has been the introduction of improved thermal performance criteria for new residential construction and the promotion of improved thermal efficiency of fuel oil and natural gas furnaces.

The emphasis of the Ministry of Education is upon more efficient operation and maintenance of plant and classroom facilities, from both the short term and long term standpoint. It has also initiated educational programs that promote conservation.

The goal of the Ministry of the Environment is to demonstrate the relationship between the conservation of energy and the improvement of the environment through determining the net savings that can result from the recycling of products and the reclamation of wastes. The Ministry of the Environment is also working with the Ministry of Energy on the environmental aspects of energy production from waste.

The Ministry of Government Services is continuing a program of improved management of energy used in government buildings and is instituting a program for analysing energy consumption in all public buildings financed largely by the Province. The Ministries of Correctional Services and Community and Social Services are assisting.

The Ministry of Health is concerned with the maintenance of the best possible environmental control conditions in hospitals, while reducing excessive light levels and ventilation that are beyond essential levels.

The Ontario Housing Corporation, under the direction of the Ministry of Housing, has called for a higher

standard of insulation in its buildings, including the fitting of double-glazed windows. It is expected that annual savings of 20 per cent will result.

The Ministry of Industry and Tourism is undertaking a variety of projects designed to provide assistance, information and technical data to industry, through direct consultation at the plant level, as a means of encouraging the industrial sector to improve energy management and effect conservation techniques. Individual companies co-operating with the Ministry and undertaking plant energy audits have identified average annual energy cost savings of 17 per cent.

The Ministry of Natural Resources has participated in studies of the beneficial use of reject heat from electrical generating stations for aquaculture and agriculture. It is developing a remote sensing and surveillance capability for surveying urban centres and detecting heat loss from buildings.

The Ministry of Transportation and Communications determines and evaluates efficient fuel saving techniques through analysis and testing, studies and development, specification and design modification and through evaluations related to fuel economizing. It has established guidelines for government vehicle purchases and use and is targeting for a four per cent increase in energy efficiency. This Ministry, in addition, is heavily involved in the planning and promotion of urban transit systems through its Ministry planning and liaison role with other transit agencies. In conjunction with the Ministry of Energy and the Ontario Trucking Association it has set up an Advisory Council on Energy Conservation in the Trucking Industry.

The Ministry of Energy is attempting to establish a true ethic of energy conservation in the province. The conservation ethic is applauded by the people of Ontario but to this point the commitment is largely philosophic. It is the objective of the Ministry to convert this philosophic acceptance to individual commitments to personal economy in the use of energy. Every individual must relate energy conservation in terms of his individual needs, costs and benefits and must eliminate both unnecessary use and overt waste.

The activities related to energy conservation are varied and far-reaching and progress is being made. However, energy is still being wasted or being used inefficiently. There is a continuing and urgent need for a commitment by every individual, corporation, commercial undertaking and government to the most efficient and economic use of energy in Ontario.

SECTION VI

ENERGY SUPPLY AND DEMAND AND ONTARIO'S ECONOMIC PROSPECTS

In the jargon of the economist the demand for energy is "derived" -- it is determined by the production processes, the style of our lives and the way in which we make our living. Demand for other products is also derived but energy is different in that it forms an essential part of all production and services. Without it our production processes could not continue and the way we are accustomed to living would disappear.

Energy is addictive; it creates its own continuing demand because our habits and the structure of our society alters in response to the cost and availability of energy. We have, for example, created a stock of housing, commercial buildings, transportation equipment and industries and a lifestyle that are predicated upon a plentiful supply of relatively low cost energy. The future will have to accommodate to supply constraints and higher energy costs.

Changes already have taken place. Earlier sections of this report have made it abundantly clear that increasing our supplies of energy at rates equivalent to those of the 1960s will only be achieved at great cost and an increased dependence upon imports. It is by no means assured that we will be able to continue to buy on the world market all of the crude oil we will need prior to the development of renewable sources and the price is likely to continue to increase. The trend of the 1960s, marked by high economic growth based upon relatively cheap and plentiful fuel and electrical energy, has been halted and probably reversed.

Ontario, in common with other industrial countries, must examine its energy future from a radically altered

energy perspective. In the planning of our future it is foolhardy to assume anything other than that the availability and cost of energy will be an increasingly compulsive force moving us in the direction of change.

It will affect the requirement for energy efficiency in our existing stocks of houses, cars, factories and commercial and public buildings but it also must be expected to fundamentally change the future shape of our cities, alter our transportation modes and necessitate reassessment of our personal priorities and expectations. Living in an energy-scarce and energy-costly world will involve a major adaptation.

It is particularly difficult to predict the amount of energy that will be required in the years ahead. The normal practice of predicting the future as a modified extension of the past is likely to prove to be remarkably inaccurate when the cost of supplying additional energy has escalated so steeply, when there is likely to be a varying degree of scarcity of the different energy forms and when changes in community planning and lifestyles are in prospect.

Further, the capital demands implicit in the expanded production of more costly energy can be expected to reduce economic growth because of the increased proportion of our available capital that will have to be committed to energy-related projects. The cost of imported crude oil will have a negative impact on our national balance of payments.

Indeed, the cost of energy developments is already affecting the availability of capital for other purposes. In 1960 capital expenditures related to fuel and power

amounted to 12 per cent of Canada's total capital expenditures. The proportion in 1976 had increased to about 18.5 per cent in spite of the fact that over this entire period our total capital expenditures had remained a fairly steady 23 per cent of our gross national product. The increase in investments in energy supply projects as a proportion of our available investment funds is not likely to be reversed. The cost of providing increased units of energy has increased and is likely to increase further.

The major economic forces related to energy supply can be expected to eventually reduce the rate of increase of per capita real income in Ontario, the impact being felt by consumers in the form of real price increases. If energy prices increase more rapidly than the prices of other commodities and increases in the price of energy do not proportionately reduce the amount purchased, the share of the family budget spent on energy will increase.

The implication of such a shift in the proportion of the family budget spent on energy is that there will be less money left over to spend on other things and to save. And if savings as a proportion of income decreases the result will be that the private sector will be less able to raise the capital needed for energy projects.

The energy consumption per capita in Canada is approximately double that of Sweden and Germany. The response that "our style of life is different" is quite correct. The United States Federal Energy Agency compared the United States and Germany and found that, on a per capita basis, the average German uses 1 per cent of the air conditioning and clothes drying that an American does, and that there is ten times as much rail traffic per capita in Germany.

Heat-on-demand is typically used in Germany and, to cite one industrial example, energy use per unit of production of pulp and paper in the United States is 75 per cent higher than in Germany. And Canada parallels the United States much more closely than it does Germany.

There is no quick, easy and painless way in which Canada can adjust its per capita consumption of energy to the practise in Germany and Sweden. Such countries have a long history of relatively high-cost energy and, as a direct consequence, their industry is more labour intensive and their cities and lifestyles have not been developed in an environment of low cost energy. Canada's historical experience is different: the effect of low cost and plentiful energy was to create in Canada, as in the United States, energy-intensive industry and an energy-dependent lifestyle.

Trade-offs are now going to have to be made. Increased energy production can be bought at a price. Energy saving projects, such as public transportation, district heating, energy-efficient communities, can also be bought at a price. Decisions will have to be made as to the proportionate amounts that should be spent on each.

That a change in energy use patterns will have to occur is now beyond question. The economic pressures will combine with environmental considerations to force adjustments. The issue is the extent and pace of change and the kind of society that will emerge. It will be different. Whether it will be better or worse is speculative.

SECTION VII

A FRAMEWORK FOR ENERGY POLICY PLANNING

The renewable sources of energy that served mankind for thousands of generations -- the power of domesticated animals, wind for sea transport, wood, water wheels -- now provide a minor portion of the energy we use. Running water, directed through turbines, is an important source of electrical power but does not have the potential for expansion that would enable it to keep pace with growing energy demand. In Ontario, in particular, the major hydraulic sites have long since been developed.

The world is currently powered with non-renewable energy sources, primarily fossil fuels and uranium. The interim nature of crude oil, natural gas and coal is evident. Uranium is presently depletable also although, as noted, if work on advanced fuel cycles is successful the useful life of Ontario's and the world's stocks of fissionable and potentially fissionable materials (uranium and thorium) would be greatly extended.

The total quantity of fossil fuels in existence depends on past geological processes but the useable reserves, as with any resource, also depend on technology and price. At higher prices marginal resources may become recoverable reserves and new exploration may convert previously undiscovered resources into identified and recoverable reserves.

Higher prices that compensate for higher costs or new discoveries may increase total reserves but the resource base obviously will never expand.

Nor will all of a given resource ever be recovered. Costs become prohibitive, a condition that is reached sooner when environmental costs are included. At a point the amount of energy required to extract energy is equal to the amount extracted and, irrespective of price, continued production becomes impractical.

The fact is that fossil fuels are nothing more and can be nothing more than an interim source of energy. In fact, in the million year history of mankind on earth, fossil fuels have been a major source of energy for less than a century and a significant source of energy for no more than a couple of centuries. Within the context of the history of mankind the total life of fossil fuel resources inescapably will be very short.

This fact dictates the thesis of this report. The central perception that influences its direction is the fact that the non-renewable energy resources -- crude oil, natural gas, coal and uranium -- are no more than a bridge between the renewable energy sources of the past and those of the future and the bridge is not very long. The resources must be managed within that context.

Because national energy supply and demand projections diverge, with the divergence increasing the further they reach into the future, in effect they are only indicators of trends; the projections contain too large an element of attempting to outguess the future to be a sure guide to decision-making.

Ontario must, nonetheless, plan a response to the emerging energy realities. A substitute for reliance upon uncertain projections is to elaborate a representative set of alternative energy futures, trace their implications, select the most desirable and design policy that will move the province in this direction.

For the energy planning process that is suggested it is useful to define a three-phase time frame -- the "near term", the "long term", and a "transitional phase". The

"transitional phase" will overlap both and will be marked by an increasing emphasis on renewable resources and a decreasing reliance on non-renewable sources.

The specific duration of each phase will be estimated but obviously is susceptible to considerable error. The important consideration is the perception.

Near Term

The "near term" is defined as being the interval in which we will continue to depend overwhelmingly on non-renewable sources of energy.

The reality is that this term will not be very short. It was noted in an earlier section of this report that the Ministry of Energy does not anticipate that renewable sources of energy will provide more than about 1 or 2 per cent of the energy that we use in the year 2000. Projections by both the Government of Canada and that of the United States are roughly parallel. This being the case, the "near term" will reach beyond the turn of the century and, for the purposes of this discussion, it can be speculated that it will at least extend to the end of the first quarter of the next century.

The rather sobering implication of this conclusion is that for some fifty years we will be primarily dependent for our energy supply upon coal, uranium, crude oil and natural gas from conventional and frontier sources, supplemented with synthetic oil and gas from the heavy oils and oil sands of western Canada and crude oil and possibly natural gas purchased on the world market.

Given that we are going to rely upon traditional sources for fifty years -- and this prospect carries a much narrower margin of supply security than is desirable -- the first question that must be asked and answered is whether Ontario should place its reliance upon a very much larger proportion of imported oil or should encourage a Canadian commitment to the expanded production of energy from domestic sources.

Reliance upon foreign sources would place great pressure upon Canada's balance of international payments. Reference was made to this in an earlier section of this report.

Paralleling this concern must be a concern as to the supply and demand balance for energy in the world and the question as to whether the world supplies will be sufficient to satisfy a growing world demand over the "near term".

There is reason to expect that it will not.

The ultimately recoverable reserves of crude oil that had been defined but not exploited as of January 1, 1976 are estimated by the International Petroleum Encyclopedia to be about 650 billion barrels. Of this total half is in the Middle East with 6 per cent in North America.

More than two-thirds is in countries that constitute the membership of the international cartel -- the Organization of Petroleum Exporting Countries. It has been estimated that a further 1 trillion barrels remain to be discovered, most of this additional crude oil being outside the borders of the countries of the Middle East and much of it under deep water or in harsh environments, such as the Arctic regions.

Historically about 15 to 20 billion barrels a year have been discovered. Of the potentially recoverable ultimate reserves of about 1.7 trillion barrels it is estimated that about a trillion barrels would be economically recoverable.

In 1975 the world consumed crude oil at the rate of 55 billion barrels a year and, assuming no increase in crude oil consumption in the future, this would mean that all the crude oil would have been discovered and consumed by 2025.

But it is not at all probable that the rate of annual consumption will remain constant. During the 1960s world consumption grew at about 7 per cent a year and it is projected to increase at a rate of 2.5 to 4.0 per cent per year in the period 1975 to 1990.

If one assumes a growth rate of 3 per cent a year, a conservative assumption, the total crude oil consumed between now and 2015 would be 1.5 trillion barrels, and this is half a trillion barrels more than the estimated economically recoverable resources of the world.

Nor can it be assumed that the nations which own the major portions of the world's crude oil resources will continue to sell oil at increasing rates until all of their reserves are gone. It must logically be accepted that they will retain reserves for their own long term use and will reduce or discontinue exports well before their oil fields are pumped dry.

On the evidence of existing knowledge it is not safe to assume it will be possible to buy substantial quantities of crude oil on the world market beyond the turn of the century. At a minimum the requirement for supply security demands that before 2000 is reached Ontario must have an acceptable alternative to the buying of crude oil in the world market.

Relative to projected demand the world is somewhat better supplied with resources of natural gas. Estimates of proven reserves approximate 2,500 trillion cubic feet and "probable" and "possible" additions could increase this total very substantially.

Present annual world natural gas consumption is about 47 trillion cubic feet and, assuming this rate of production continued unchanged, known reserves would last for fifty years. In fact consumption of natural gas is increasing more rapidly than crude oil; major supply additions will be required.

Natural gas is likely to be somewhat more available than crude oil in the last one or two decades of the assumed "near term". If natural gas follows the probable price trend of crude oil, however, it is likely to be very expensive because of the high cost of liquefaction and regasification. If natural gas is to be transported across oceans it must be compressed into a liquid for movement by ship, and the process is very costly.

The availability of crude oil and natural gas from domestic sources has already been discussed. Our crude oil supply and demand is not in balance and through the 1980s, at least, Canada cannot be expected to supply the amount

of crude oil that will be consumed domestically. The present "surpluses" of natural gas in western Canada will not continue and between the mid and late 1980s shortages of natural gas from conventional sources will develop.

There will be a requirement for additional natural gas supplies and there is no evident alternative to the construction of transportation facilities from the frontier regions.

Canada has very large deposits of oil sands and heavy oils. Synthetic oils from these sources appear to be the only practicable domestic source of additional oil supplies. Coal is likely to be required for a larger proportion of the energy Ontario uses, whether used in its natural state or converted into electricity, a gas or liquid. Uranium- fuelled electrical generating stations will need to increase in importance and, with coal-fired stations, will constitute the major portion of an expanded electrical generating capability in Ontario.

Long Term

The "long term" is defined as the period in which we will have moved away from non-renewable energy sources and will overwhelmingly rely upon renewable sources as well as on those sources for which fuel will likely continue to be available, such as fusion and advanced fuel cycle reactors which would extend the useful life of uranium as an energy fuel source well into the long term.

The start of the "long term" is highly speculative. The technology has not yet been developed and, in spite of the world-wide commitment to renewable energy research and development, the lead time is likely to be long. But the non-renewable sources will have been severely depleted in

fifty years. If that proves to be the case they will no longer be available in sufficient quantity to provide energy for the world, and renewable sources will be the only option. Partly because there doesn't seem to be very much choice, it is assumed for the purposes of this report that major reliance will shift to renewable energy sources or such essentially renewable sources as advanced fuel cycles, by about 2025.

Predictions as to the combination of renewable energy sources and delivery systems that will serve us in the long term are highly speculative. But some predictions can be made that have a reasonable probability of proving to be correct.

In Ontario electricity can be expected to continue to play a key role in the energy systems of the long term. A great deal of effort is being directed toward the development of advanced fuel cycles and success would mean that our uranium reserves would continue to be a potential source of energy far into the long term. Other methods of electrical generation, - still in preliminary stages of development, could prove to be important; these include fusion, magneto hydro-dynamic units, such direct conversion devices as solar cells and fuel cells and, for local applications, wind generation.

The end uses of electricity can be expected to expand. It is likely to dominate rail transportation and could even become important in road transportation; techniques for improving the efficiency of overall energy use, such as the use of heat pumps, will increase the use of electricity; if advanced solar energy heating systems are developed electricity probably will be used for heat distribution and as a supplementary heat source and electricity may be used for the production of such other energy forms as hydrogen.

The "long term" is likely to be characterized by the widespread utilization of such manufactured fuels as hydrogen, synthetic methane and methanol; transportable, high-energy-content synthetic fuels are currently the most promising long term source of energy for specialized uses such as, for example, aircraft propulsion.

A variety of techniques are being investigated for the production of synthetic fuels. An interim step -- used in the latter half of the "near term" and extending beyond --is likely to be the conversion of coal to liquids and gases so that its energy can be obtained without the undesirable effects of direct combustion. Electricity, as noted, may be used to produce hydrogen. Biomass technology, relying upon plant and animal material as a source, may prove to be a means of producing large quantities of synthetic fuels.

In the "long term" the efficiency of energy use will have been greatly improved. Existing communities will have been modified and energy efficiency improved, energy efficient new communities will have been designed and constructed, energy consumed in transportation will have been reduced to a minimum and the efficiency of industrial processes improved. As a product of periodic supply shortages, higher prices, continuing and increasing concern as to the ecosystem and expanded public information programs it is reasonable to expect that society will have made a major commitment to reuse, recycling and conservation and will, in fact, have become a "conserver society".

Transitional Phase

The "transitional phase" is the period in time during which those actions must be initiated and completed that will result in the transition from a major reliance upon non-renewable energy sources to a major reliance upon energy sources that are classified as renewable.

Activities that are specific to the "transitional phase" will increase in intensity from the present to a peak and may decline in intensity as their purposes are accomplished and society moves toward the energy sources and practices of the "long term".

In effect, it will extend from the present until its purposes are accomplished, an accomplishment that is postulated must be achieved by the end of the first quarter of the next century.

In other words, the "transitional phase" will correspond in time with the "near term" but the period of maximum intensity of effort can be expected to extend from about the mid-1980s to about the mid-2010s.

The increase in the intensity of activity in the "transitional phase" will necessarily be gradual. A major undertaking will be the pressing back of the energy-related technological frontiers. The size of inputs that can usefully be made relates to the stage of a program. Money and manpower inputs can only be usefully increased as fundamental research and laboratory work proceeds through the pilot and demonstration project stages to plants that are capable of producing economical energy on a commercial scale: the later and larger projects are much more demanding of resources than the earlier activities.

This is also true of other activities of the "transitional phase". Our society has been constructed under the influence of plentiful supplies of relatively low cost energy and as this alters in the direction of scarce and costly energy the public's priorities and practices will alter. Changes in social values are necessarily gradual.

Increased resources will become available for investment in the energy forms of the future, as progress is made in the development of economic and renewable sources of energy, as consumption habits alter and as the efficiency of energy use improves in domestic, commercial and industrial activities.

Because the "transitional phase" overlaps the "near term" so substantially this will not be equally true in the immediate future. The cost of maintaining and expanding our supplies of non-renewable energy sources to satisfy the requirements of the "near term" will make very heavy demands upon our resources of labour, materials and capital; in the "transitional phase" the requirements of the "near term" and the requirements of the "long term" will compete for productive resources.

The prospect of the "transitional phase" is that public policy formulation will be difficult. Judgements will have to be made between projects that will expand the availability of the conventional fuels of the "near term" and the anticipated requirements of the "long term" in which non-renewable resources will have been depleted and failure to have provided an acceptable alternative will spell disaster.

Further, the "transitional phase" will have to be completed prior to the disappearance of the conventional sources of energy. It must be assumed that large quantities of energy will be required to bring into production the newly-designed energy facilities of the future, and enough of the conventional fuels must remain to construct the projects that will provide the renewable energy of the "long term", at least for an initial period.

SECTION VIII

CONCLUSIONS

Policy planning in Ontario should be structured on the basis of an energy future that is perceived as "near term" and "long term", the former being overlapped with a planned "transition phase".

The policy objectives of the "near term" and the "long term" are the same. Both are directed to providing the consumers of Ontario with secure and adequate supplies of energy at the lowest feasible cost. It is evident, however, that the sources of energy in the two periods will be different and, apart from a continuing commitment to energy conservation and the most efficient possible use of energy, the policies with which the two time frames must be confronted are very different.

It has been emphasized in this report that the "near term", which may extend fifty years into the future, is that period in which we will continue to rely upon depleting sources of non-renewable energy. But before we reach the end of this defined "near term" it is critically important that a transition should have been made to the "long term" -- the period beyond 2025 when we will have to be capable of supplying the energy we need from renewable sources with a greatly reduced dependence on the energy sources we use today.

There is a serious danger that the policy needs of the "near term" could be so demanding that the approaching requirements of the "long term" would be neglected. The consequences of such neglect could be catastrophic. The disappearance of our resources of crude oil and natural gas can now be predicted with a reasonable degree of reliability and that within three or four decades they will

be insufficient to provide the energy we need. It is a fact that our food systems, health systems and lifestyle have been constructed upon the assumption of continuing and adequate supplies of energy. It follows that in the absence of adequate energy supplies our life support systems will become inoperative. It further follows that if failure to plan for our long term energy future carries with it the risk of the failure of essential life systems it introduces a further risk of the disappearance of western civilization as we know it.

This fatal scenario is possible. If it is to be avoided, there has to be urgent and relevant energy planning in the world, in Canada and in Ontario. That planning must be directed to satisfying the energy requirements of the near term and, concurrently, creating the capability to effect a smooth transition to the energy forms that will power the long term.

As has been emphasized throughout this report, the energy sources upon which Ontario depends are not renewable and they will be depleted. They will not, however, all become equally unavailable at the same time. Projecting supply trends can be hazardous, as noted, but conclusions with respect to our energy prospects must be reached. It is important to make these conclusions specific and public in order that others who have arrived at different conclusions can challenge them. To the extent that there is universal agreement as to the validity of assumed facts the design of policy is made less difficult.

Conclusion #1: Crude oil from domestic sources will be in seriously short supply by the mid-1980s, forcing Ontario to rely to a major extent on imported crude oil.

Conclusion #2: While the production of synthetic oil as a result of intensive development of Canada's oil sands or heavy oil deposits could lessen the dependence on imported oil, it is probable that the deficit in domestic supply will persist through the 1980s.

Conclusion #3: Reliance upon the expectation of the discovery of major new deposits of crude oil in Canada is too speculative to be incorporated into Ontario's "near term" planning.

Conclusion #4: Shortages of natural gas will develop in Ontario in the mid-to late 1980s even if domestic consumption does not expand beyond current levels, unless there is early construction of transportation facilities for the movement of natural gas to Ontario markets from the Arctic.

Conclusion #5: Energy from coal will not be capable of compensating for a deficit in the supply of crude oil and natural gas in the 1980s and 1990s as a consequence of production, environmental, transportation cost and other constraints.

Conclusion #6: An increasing proportion of the energy used in Ontario will be in the form of electricity.

Conclusion #7: Uranium-fuelled electrical generation is of growing importance for Ontario and the effect of a withdrawal from the nuclear commitment would be serious in terms of the energy prospects of the province. Ontario now has no economical and practicable alternative to the use of coal and uranium as fuels for new generating capacity; a number of considerations will result in a primary emphasis on new uranium-fuelled electrical generating capacity.

Conclusion #8: Every effort must be made to assure that nuclear facilities and the nuclear cycle continue to be as safe as other energy forms and are seen by the public to be as safe.

Conclusion #9: Solar space heating, and other prospective sources are not capable at the present state of technology of producing energy economically or of providing a significant proportion of the energy used in Ontario. Nor are they likely to be throughout most of the "near term".

Conclusion #10: Basing future energy policy on the expectation that a single technological breakthrough will resolve Ontario's energy problem is unwise and even dangerous.

Conclusion #11: Investments and incentives for conservation and efficiency in energy use must be afforded high priority by Government and the public: it will have important environmental implications; by narrowing the gap between domestic energy supply and demand and thereby reducing imports it will have positive economic implications; investments in measures to increase efficiency and reduce energy demands are likely to be more productive over the long run than the supply investments that are displaced.

Conclusion #12: Conservation and efficiency of use, notwithstanding their importance, will not eliminate the need for increased energy supply.

Conclusion #13: The energy supply investments that will be required will make severe demands upon the capital available in Canada or available from abroad for use on projects in Canada.

The preceding conclusions with regard to the energy supply-demand outlook, and the importance of various energy forms, leads to a series of conclusions of a policy nature.

To begin with, it is irrational, in the "near term" to prejudice the economy of Ontario and of other parts of Canada by unnecessarily escalating the prices of crude oil,

natural gas and coal. The price should relate to the actual cost of the discovery, development, transportation and conversion of these energy sources and should not be moved up in response to the appetites of governments in Canada for increased royalties or tax revenues: prices in Canada should not be related to world prices and ignore the actual cost of delivering energy in specific forms to Canadian consumers from Canadian sources.

Conclusion #14: The price of energy from sources in Canada, including natural and synthetic gas and crude and synthetic oil, as well as coal and uranium, should not be permitted to escalate in response to the monopoly selling power implicit in growing shortages, but should relate very directly to the cost of producing and delivering the energy in useable form.

Conclusion #15: The price of energy should be a weighted average of the actual cost of producing energy at higher costs from new sources and lower costs from established reserves.

Conclusion #16: Increases in the cost of energy impact most severely on those least able to pay. Further, unnecessary increases in price unnecessarily damage industrial economies in Canada. It is inequitable to consumers and irrational in terms of industrial development to escalate price in an attempt to reduce energy consumption.

Conclusion #17: Planning in Ontario should be based upon the expectation that, because the cost of producing energy will continue to increase, the price of energy to the consumer will continue to increase.

Nor can costs be ignored in making selections between existing and alternative energy sources. The well-being of consumers and the competitive strength of the province could be undermined if Ontario (or Canada) permitted itself to become irreversibly and prematurely locked into energy production processes that subsequently proved to be less efficient and less economical than some alternative.

For example, the cost of extracting oil from the oil sands, using the present technology, is relatively high. The effect discussed in the previous paragraph would result if commitments to a number of plants using the existing technology were made and a subsequent technological development produced processes that would extract the oil from the sands at a very much lower cost.

It has been concluded that natural gas will be in short supply in the mid-to late 1980s and there is no evident alternative to natural gas from the frontiers. Synthetic gas is theoretically available from various sources -- coal, biomass -- but at the current stage of technology these sources are not economic sources of gas in commercial quantities.

The risks of misjudging the future are high and, in an effort to reduce the penalties of misjudgment, policies and programs must be as flexible as possible in order that negative effects can be held to a minimum. But the

greatest risk of all is a serious and continuing energy shortage, and irrespective of the clustering uncertainties, judgments must be made and decisions must be taken that will tend to reduce this over- riding danger.

Conclusion #18: Construction of transportation facilities that will connect the gas resources of the Mackenzie Delta to the industrial markets of southern Canada should be undertaken at as early a date as possible, subject to appropriate social, economic and environmental safeguards.

Conclusion #19: Facilities for the extraction of synthetic oil from the oil sands or from the heavy oils should be expanded at the rate that available capital permits, subject to the price to consumers of the resulting oils bearing an appropriate relationship to crude oil from other sources such as, for example, offshore.

Conclusion #20: The most effective possible use must be made of the capabilities, facilities and institutions of the private sector that are now engaged in supplying energy to the consuming public. The Government of Ontario should not attempt to displace or compete with private sector organizations that are effectively performing the task of supplying energy and nor should government in general tax the private

sector to such an extent that it is unable to undertake the high risk investment frequently associated with energy development.

Conclusion #21: Government of Ontario investments in research, development and demonstration projects should be so planned as to complement those of other governments and private corporations; attention should be focussed on undertakings that may have important results but are not economic for private investment.

Conclusion #22: A Canadian Council of Energy Ministers should be formed and funded by all governments in Canada. It should be supported by a Research Secretariat which has the potential of providing a national focus on questions related to the supply and demand of energy in Canada.

Conclusion #23: Energy forms from Canadian sources will not deplete simultaneously. Their use should be planned by taking into account the expected supply life and the uses for which specific forms are particularly well suited.

Conclusion #24: The acceleration of planning and the related investments and incentives that will advance the transition to renewable energy sources must be considered to be very urgent.

All forms of energy conversion require vigilance in assuring that minimum damage is done to the environment. The fact is there are adverse environmental consequences associated with the extraction, transportation, processing and use of all energy forms. The forms of the future may reduce environmental costs but it cannot be presumed that such costs will be eliminated. At all times the environmental costs or risks must be weighed against the costs of having insufficient energy supplies.

Conclusion #25: Environmental considerations must be accorded a high priority in efforts to resolve energy supply problems and with respect to energy use.

It bears repetition that the requirements related to energy planning in the "near term" are likely to be pressing and urgent and will make heavy demands upon all relevant resources: it equally bears repetition that the effects of the failure to provide energy sources that are an alternative to the depleting non-renewable sources prior to their depletion -- whether that is destined to be at the end of the first or second quarter of the next century -- would be very serious in terms of the future of this province and of western civilization.

Conclusion #26: The Ontario Government commitment to research, development and demonstration related to renewable energy resources should be intensified and, over the next five years, the commitment of

capital and research capability directed toward accomplishment in this area should be multiplied several times over.

A comprehensive energy policy must extend well beyond the design of programs to increase the available supplies of energy or to reduce energy waste. Energy is pervasive and energy policy must be almost as pervasive: energy use must be a vital component in the planning of transportation, industrial development, land use, community planning and many other economic or social activities.

Because energy inter-relationships run through the whole community policy planning becomes complex. There is a continuing and growing requirement for co-ordination within the various Ministries of Ontario, among governments and between the public and the private sectors.

This co-ordination now exists to a degree but assuring that all policies are effective and that effort by one agency is not prejudiced by action by another is obviously an on-going and continuous process.

Planning in Ontario should be comprehensive and continuous in meeting the requirements of the "near term", the "transitional phase" and the "long term". It should be equally capable of responding to developments in the area of non-renewable energy research, as well as co-ordinating the policies of the "near term".

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